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TECHNICAL ASSISTANCE AND TRANSFER OF APPROPRIATE AND AFFORDABLE TECHNOLOGY

Technical assistance and transfer of appropriate and transferable technologies to developing countries

Paper submitted by the United Nations Secretariat**

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If the mapping sciences are to contribute to the challenges facing the developing nations of the world today then first the nature of these challenges must be understood. If we do not start with a clear understanding of the problems then our contribution to their solution may not be a useful one. A central argument of this paper is that the modern mapping sciences have the potential to be of utility in the struggle for development but that potential has yet to be fully realized. Education and training have a critical role to play in this respect, especially in ensuring effective technology transfer.

The term "developing nations" is a euphemism used by the rich to describe the poor. Although difficult to define, "development" includes at least four components. These are:

1. Increased economic growth

2. Improved equity and the distribution of wealth and opportunity

3. Control by the people of their own destiny through participation in decision-making

4. The achievement of qualitative transcendental values, e.g. religion.

Development cannot be defined in only quantitative terms and differs over both time and space. It is a dynamic concept. It is best defined in terms of the aspirations and values of people in their own social context and is thus probably only meaningful at the sub-national scale.

Development is an optimistic term. It suggests progress and forward movement but for many parts of the world there is no compelling evidence that development, however defined, is taking place. Africa, for example, is generally held to be in crisis and over the last decade the quality of life for the majority of Africans has been declining in both absolute and relative terms. The recent and tragic drought affecting most of Southern Africa is compounding problems and the term "development" rings very hollow in African ears. Increasing degradation would be a better description of what is happening at present.

The Secretary General of ECA has identified three major manifestations of this debilitating crisis:

1. The major macroeconomic indicators declined over the decade of the 80s

2. In both industry and agriculture production mechanisms disintegrated and the same applies to much of the infrastructure

3. The provision of education, health and housing declined at an accelerating rate.

To this list could be added an increasing deterioration of the physical environment. The figures for Africa, in terms of indicators such as per capita income, wage employment, inflation rates etc. are all quite depressing and are mirrored to some degree in other parts of the world although fortunately not to the same degree.

There are also bright spots in the picture. Latin America after the "lost decade" of the 1980s is beginning to show remarkable signs of economic recovery and growth. The spectre of the debt burden is now beginning to fade and net transfers between South and North are beginning to take on more reasonable proportions although we still have a situation where net capital flows from the South to the North which is the reverse of what is required for economic growth.

In Asia there have been success stories such as those of the four Asian tigers, the newly industrialized countries of Korea, Taiwan, Hong Kong and Singapore. The two most populous countries in the world, China and India, have made impressive progress although in the case of India the macro-indicators mask increasing internal disparities between the rich and the poor and even the current macroeconomic situation gives cause for concern. In both nations population growth continues to be a problem despite progress on birth control which, in the case of China, has involved measures which seriously limit individual freedom. The large absolute numbers of people mean that even modest rates of population growth in percentage terms pose enormous problems, especially where the factors of production, such as arable land, are limited. For many nations rapid economic growth must take place simply to maintain the status quo. In this respect the progress made in many Asian nations is tenuous and there are real limits to their growth.

It is not surprising that in these circumstances the environment has come under increasing pressure. The issues involved were well described in the Brundtland Report which set the stage for the recent conference in Rio. The difference in perspective between North and South which emerged again in Rio is interesting and important. Environmental degradation by the people of many developing nations is not an act bred simply out of ignorance and greed but often out of desperation and the need for survival. To talk of development for many of Africa's peoples, for example, is incorrect - we are really dealing with the struggle to survive. Environmental problems cannot be divorced from development problems. Developing nations are being asked by industrial and post-industrial societies to meet the costs of a development path before they have had the opportunity to experience the benefits. The reason for this concern is that the problems of environment cannot be isolated in space because national action or inaction often leads to impacts which are felt not only on national territory but on a regional, continental or even intercontinental scale. Although the environmental problems of surplus such as those of pollution by industrial societies are different from the environmental problems of poverty, there is an inexorable link between the two.

The same, of course, applies to many of the other problems facing developing nations. Development thinking tends to go in phases. It is fashionable these days to look for the solution of development problems at the national scale and "structural adjustment" is the remedy suggested by the World Bank. A major problem with this is that it tends to underestimate the importance of North-South relations in the development problematique. There are those who argue that the success of the "First World" has been built on the exploitation of the Third World and that this is continuing in new and more subtle ways long after the period of formal colonialism is over.

Although these analytical perspectives are controversial there is no doubt that relationships between the First and Third Worlds have been unequal for centuries and continue to be so today. An understanding of these relationships is critical to an understanding of the context of development.

Recent changes in the geopolitical scene make the situation even more complex. Dramatic changes have taken place in the "Second World" - the former Soviet bloc. Almost overnight a revolutionary change has taken place in the relationships between the First and Second Worlds. It is not clear what the long-term impact of this will be on Third World nations but there are already clear signs of change. It is likely that increasing portions of development assistance will be redefined and redirected and that commercial loans and private investment will also seek new outlets in the Second World rather than the Third. Technology transfer, overseas development assistance and private loans and investments are important elements in First World-Third World relationships. The Second World was a player in this equation and was, in fact, a competitor with the First World for influence in Third World countries, a competition that many Third World countries often used to their advantage. Recent events have, however, changed all of this. The Second World is now a competitor with the Third World for First World attention.

The techniques of the modern mapping sciences are very much First World technologies. Their utilization in the Third World will, to some extent at least, depend upon the ways in which technology transfer takes place, as much as upon the nature of the technologies themselves. If the First World finds new and more politically compelling outlets for its interests the present nature and scale of that technology transfer may change. Thus to understand the role of the mapping sciences in the developing nations it is necessary to understand the challenges and context of development itself, which is constantly changing. This is not primarily a technical problem and technology transfer is not a purely technical problem. The appropriateness of the transfer process is as important as the appropriateness of the technology itself.

Appropriate technology is best defined as that most appropriate to the task. In some cases this will be the highest technology available; in others more modest solutions will be required. Appropriate technology is not always equated with simple technology. In all cases, however, the solution chosen must be appropriate to the development context in which it is to be applied. Here, technology is only one of a number of complex socio-economic and political factors to be considered.

The mapping sciences in the developing world

In developing nations, apart from a few research applications and exploratory projects, modern mapping technology was not seriously applied prior to 1980. The 1980s saw a steady expansion of the applications of modern mapping science technologies after 1986. This has largely been a result of rapid technological change in a number of related fields. Developments in remote sensing have been particularly important in increasing data availability. Developments in GPS have also been particularly impressive so that we have vastly increased amounts of available information (especially on the environment) available with a high degree of locational accuracy. The increasing power of the microcomputer has also been a key factor together with the fact that costs of hardware per unit of computing power continue to decrease. The year 1986 was particularly significant in this respect as it was in that year that the Intel 386 chip was introduced giving a quantum leap in terms of micro-computing power which one author claims had as dramatic an impact on GIS as the impact of the changes in East and Central Europe had on the world political scene. This development has, of course, continued with the introduction of the 486 chip and related developments. Added to this have been software developments, better database structures, new storage devices, and a host of other technological developments.

Applications of modern mapping science technologies in the developing nations expanded considerably during the latter part of the 1980s but when these applications are examined they are often found to be initiatives funded or supported by international aid agencies and many are pilot or research projects as opposed to operational systems. They also often tend to rely on outsiders and are rarely controlled by indigenous scientists. The need for indigenous control is an issue of paramount importance. Vendors typically deliver "turn-key" systems which usually include a training component. The vendor will maintain and update the systems for a price if required, but the use of that system is then in the hands of the purchaser. This assumes that the purchaser has a clear idea of why the system will be useful and how it will be applied to development problems. This demands a considerable base of indigenous knowledge and expertise.

Modern mapping technologies are new technologies in developing nations and their introduction is coming mainly from the outside. It can also be argued that so far the actual contribution of the mapping sciences to the solution of the problems of development that I outlined earlier has been largely marginal. A necessary, but perhaps not sufficient, first step is for indigenous scientists and decision makers to gain a greater degree of knowledge and control of this technology. The crucial question is how to obtain this socio-economic and technical command and it is to this question that this paper will now turn. One approach is to look at what has been done and what is being done to see if any lessons have been learned. One nation which has taken important steps in this respect is the People's Republic of China and it is useful to identify some of the key strategies used in that country.

The first and most obvious was that the building of indigenous capacity has been a long-term and continuing development strategy. A second is that the mapping sciences in China are applications driven with the contribution of the mapping sciences to the problems of national socio-economic development always being an important factor in determining how the mapping sciences are themselves developed. Within this general context a number of specific strategies are used.

1. In the mapping sciences China sent a number of young specialists overseas in the 1970s to learn from a variety of countries. These individuals returned home to form the nucleus of a research, training and development group in a number of key centres, especially Wuhan, Xian, Zhangzhou and Beijing. The Wuhan Technical University of Surveying and Mapping was established as early as 1956 and many of its key staff members have been trained overseas. This is a strategy which continues to this day but which is less successful than it once was as many of the bright young people are choosing not to return.

2. A complementary strategy was the invitation of international experts from abroad to lecture and teach in China.

3. Very early in the game China developed the production of its own hardware. This included computers, digitizers, plotters, multispectral scanners and synthetic aperture side-scan radar. The early models were not very good but as experience grew, quality improved and the latest models are more than adequate. In some cases China took very firm control of its own technology transfer programme by procuring a piece of equipment, taking it apart piece by piece to learn how it worked, and then producing their own clones. Foreign manufacturers did not take kindly to this but it is difficult to quarrel with the result from China's perspective. It is interesting to note that China is now exporting hardware at very competitive prices.

4. At an early stage China also began to develop its own software capabilities. In addition to indigenous software they imported and improved commercial software from the West. There are versions of ARC/INFO and other software systems in China which do a great deal more than the original. There is now a reverse flow of software from China to the West, for example, the PURSIS system.

5. The establishment of "key laboratories" has been important for China. In February 1985 China established a Laboratory of Resource and Environment Information Systems. The Laboratory is a cooperative effort by the Institute of Geography of the Chinese Academy of Sciences and the State Planning Commission. The Government of China provided substantial funds to establish this Laboratory which acts as a focal point for research and development. In 1991 the Government of China established another key laboratory in Wuhan, the Laboratory for Information Engineering in Surveying, Mapping and Remote Sensing (LIESMARS). These key laboratories play an important role in helping China to gain knowledge and information

on developments in the mapping sciences and also allow the assessment and testing of new developments for China's needs.

6. China also publishes its own journals in the mapping sciences and these are growing in number and importance. The cartographic journal Cartography is a relatively recent addition. These journals allow the propagation of information on the mapping sciences among scholars in their own language which is of considerable importance. Cartography also translates significant articles from other languages into Chinese so that these become more available to indigenous scientists. The costs involved to purchase these journals are low and in local currencies. Too often scientists in developing nations are denied access to scientific journals because of scarcity of local currency and language barriers. The Chinese solution helps to alleviate these difficulties.

7. In the processing of remote sensing imagery, China has an impressive record and has been quite innovative. It has developed its own platforms and has launched its own satellites. In addition there has also been an innovative combination of labour intensive and capital intensive technology. Extensive field checking of images using thousands of people has helped to develop a better image analysis potential.

It can be argued with some justification that China is a special case and that the scale and size of the country allow solutions to be developed which cannot be developed by smaller nations but there are elements of the Chinese solution from which others can learn. It can also be argued that when seeking help and advice in developing and introducing modern mapping technologies, developing nations might well turn to China rather than to Germany, France, Great Britain, the Netherlands, Canada and the United States of America.

Another nation at a very different stage of development and of direct relevance to this Conference is Mexico. Mexico has an excellent, high quality mapping base and in 1991/92 decided on a massive modernization of its mapping capabilities. The national mapping agency, INEGI, has analysed the challenges it faces and has decided that it must move from a traditional mapping organization to a provider of geographical information in digital format in a very short period of time. The Government of Mexico is providing a substantial initial sum of over $20 million to finance this endeavour and the process is currently under way.

The first step was for INEGI to define its requirements and this it did by producing a series of documents which went out to tender. The successful bidder was chosen in August 1992. One of the main requirements was for training and technical assistance, but, unlike the technical specifications in terms of hardware and software which were very carefully specified, the training and technical assistance components were left open. This was done deliberately in order to judge how each bidder would conceptualize the problem and what solution would be suggested. This was, in a sense, part of the evaluation process as there are a wide variety of possible responses to this question. For Mexico, the choice of the education and training approach used

is equally, if not more important, than the hardware and software elements because it is a now well-established fact that the costs of implementation and staffing a modern mapping system can be at least double the costs of acquiring the hardware and software for the system.

What sort of questions and issues arise? This paper contends that in education and training for a modern mapping system, internal capacities are key. In-house education and training are important for a number of reasons:

1. They can be geared to the realities of the particular situation in all of its complexities in a way that no outside programme can possibly be. In the case of INEGI these include not only the technical and professional needs but also the complex socio-economic context. In making substantial change in converting to a modern computer-based system from a traditional one there are many issues to be considered including the attitude of existing staff.

2. In-house capacity is ongoing and can more readily respond to changing circumstances. Training provided by outside vendors is limited in time and usually geared to the specific needs of the hardware and software supplied.

3. In-house education and training is committed to the needs of the organization, not to the utilization of a particular system which by definition is short term and profit oriented.

4. Indigenous capabilities in education and training are critical components of the human resource base on which progress in the modern mapping sciences depends.

5. As in many national mapping agencies the issue is not so much the hiring and training of new staff as the training and retraining of existing staff.

6. As the introduction of new techniques means a change from the old it is often perceived as threatening by existing staff. The education necessary to ensure the acceptability of such change extends beyond the particularities of specific skills and knowledge relating to the new techniques. To improve the chances of acceptability there must be awareness and understanding. This must include those not being immediately trained in the new system. As a minimum they must be given an opportunity to understand the new system and the need for it and if possible to have access to the general types of courses, e.g. computer literacy, which will equip them for a changing situation. This is more likely to be provided by an in-house solution than by an outside vendor. The issue of accessibility is important. If courses are available only for those directly or immediately in the conversion process then there will be a feeling of exclusion which can lead to tensions which will adversely affect the introduction of modern mapping techniques. Good education and training will not of course remove the problems of conversion but they will certainly alleviate them.

Education and training in a situation where the introduction of a radical change is being contemplated in a short time-frame such as is the case with INEGI in Mexico should therefore concentrate on two goals to be carried out simultaneously. The short-term goal must be to get the system chosen going as quickly as possible. This, of necessity, will require vendor training and this should be *in situ*. In addition to the system specific training however, there should also be a requirement for indigenous trainers to be involved in the content, structuring and methodology used in the courses. This leads on to the second goal which is the training of trainers.

In the Mexican case, INEGI already has a strong training division and a systematic restructuring of the training division to meet the challenges of the new situation may be required.

An important step in such situations is a systematic needs assessment. This should be a comprehensive one carried out by the training division itself using outside advisers for initial assistance on methodology only if required. The needs assessment should begin with the training division itself. The specific challenges and training tasks related to the introduction of the new system should be identified and matched with existing training capabilities using a matrix approach. Shortfalls will thus be identified and specific training needs for the trainers identified. The trainers can then themselves be trained either by bringing outside expertise to INEGI or by sending the trainers elsewhere depending upon the circumstances.

A second needs assessment involving all INEGI staff at all levels should be conducted in a similar manner.

It should be stressed that adjustment to modernization will be required at all staff levels in INEGI including the most senior managers. This means that management training will be required as well as technical training. It is now widely accepted that the principal challenges of a modernization project of this type are not technical but managerial and organizational.

The new technologies often demand a change in both management style and management structures. Management style must become one which facilitates team effort. In a computer-based geomatics environment the manager must utilize and depend upon the individual skills and knowledge base of his/her staff in new and largely unprecedented ways. This often requires a change from a hierarchical management structure to a flatter, more horizontal one, with a reduction in the number of management layers.

The introduction of modern mapping science also benefits from the establishment of an in-house research and development group whose task it is to keep abreast of the latest developments in the theory and practice of geomatics and to assess their implications for the ongoing modernization of INEGI.

Modernization is an ongoing process. It is not simply the acquisition of a new production system.

As a retrained staff is created new problems will emerge and existing problems will be intensified. The new training in computer-based technologies will increase the mobility of staff and, in the emerging information society, demand for such individuals, especially in Latin America, will exceed supply. To retrain staff, job satisfaction will have to be improved and this may involve both salary adjustments and incentive programmes. If such action is not taken then the benefits from the human resource development programme undertaken by INEGI at considerable costs may flow to other employers and a substantial investment will be lost. In traditional cartography, skills were highly specific and not easily transferred. The skills and knowledge required in modern computer-based geomatics are easily transferable to other fields.

INEGI's modernization project depends on people, not machines. If it is to succeed, then the same care and attention must be given to human resource development as is given to the acquisition of a new computer-based production system. This involves much more than training people to use the new system. If these issues are not dealt with the whole modernization project may fail.

Conclusion

By looking at two quite different cases - China and Mexico - support has been given to the argument that to realize the potential of the modern mapping sciences to contribute to the solution of development challenges, education and training are critical to technology transfer. An important first step is for indigenous scientists and decision makers to gain a greater degree of knowledge and control of this technology. In the case of China, much progress has been made in this respect. In the case of Mexico some suggestions have been made on how this might be achieved at a critical decision-making time for that country.

Technical assistance has a role to play in assisting developing countries with the difficult choice of appropriate technologies and in the transfer process. This is a challenge that all of the groups involved in the mapping sciences share including international bodies such as the International Cartographic Association. When dealing with the introduction of modern mapping science techniques, decision makers in the developing nations are often at a disadvantage, especially when dealing with vendors. Arnold Smith, when he was Secretary-General of the Commonwealth, had an interesting idea relating to the problems confronting the smaller nations of the Commonwealth when negotiating with the multinational corporations over their resource bases such as copper, oil, etc. He called his solution Operation Robin Hood. The Commonwealth Secretariat hired a team of experienced negotiators, many of whom had worked for multinationals themselves and this team was made available to any Commonwealth country which required it. Perhaps the international mapping community could consider an international advisory group provided at no cost to developing nations in the field of the mapping sciences. This would not be to negotiate for them but to advise on the questions to ask and the tests to make when introducing new technologies. Perhaps this group could be called the "Cartographic Crusaders" with the crusade being the more effective

application of the modern mapping sciences to the challenges of development. Scientific organizations such as ICA could provide the expertise for such a group and the funding could come from United Nations sources.